Implementing 6R Principles of the Circular Economy Concept in Sri Lankan Construction Industry

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Abstract*: This study is focused on implementing 6R principles of the circular economy concept in Sri Lankan construction Industry and provides a criteria, that can be applied to uplift the adaptation towards the circular economy concept in construction projects. Circular economy concept in the construction industry can be considered with the application of sustainable construction approaches to the whole construction process, from material extraction through building and infrastructure planning, design, and construction, as well as the ultimate demolition and the waste disposal. The purpose of the circular economy concept is to create economic strategies that allows to regenerate the materials, resources, and components while retaining their worth for as long as feasible. There are set of principles in the circular economy concept that have been identified in the literature, called 6R principles; reduction, reuse, recycle, redesign, re-classification and renewability. A qualitative data collection approach was followed to collect data and the semi-structured interviews were conducted among construction professionals. It was highlighted at the interviews that, the circular economy concept is a very new and unpopular concept to Sri Lanka and the applicability of the principles of circular economy is in the initial stage. Mostly, 3R out of 6R (reduction, reuse and recycle) principles have been applied for some of the mega-scale sustainable construction projects and the 6R principles are very new to the Sri Lankan construction industry. Lack of awareness on sustainable concepts like circular economy among construction professionals, their willingness to follow the traditional project management practices and consideration only on the initial cost of a project, than the life cycle cost of a project are the barriers which were highlighted at the interviews.*

Keywords: 6R Principles, Circular Economy, Construction Industry, Sustainability

1. Introduction

A construction can be identified as applying and management of capital, assets, specialized employees, materials, machineries and tools to get a required output using them effectively by tracing suitable drawings, technical schedules, and contractual aspects to fulfil an expectation of a client (Merrit, Loftin and Ricketts, 1996). Agu (2015) states that, the construction is a full-service sector whose goal is to turn the architect's plan and specifications into a finished project that the client approves.

Construction and demolition waste generates in a higher amount throughout the life cycle of buildings, due to lack of concern on waste disposal and waste reduction in early phases of a project (Esa, Rigamonti and Magrini, 2016). This is mostly due to usage of a linear economic model in the construction sector, and specially based on the concept of "take, make and dispose (EMF, 2015). In contrary, another economic model that has gained popularity in recent decades is the Circular Economy (CE), which is based on improved resource management (Pomponi and Moncaster, 2016). Further, the literature shows that, in order to use this concept widely in the construction industry, more information and tools must be developed (Lacy and Rutqvist, 2014).

CE in the construction is concerned with the of sustainable development techniques to the whole construction process, from material

extraction through building and infrastructure planning, design, and construction, as well as ultimate demolition and waste disposal (Tan, Shen and Yao, 2011). The primary purpose of CE is to create an economic structure that allows to regenerate materials, goods, and components while retaining their worth for as long as feasible (Grdic, Nizic and Rudan, 2020). According to the models in CE, at the end of a life of a building, the materials of that particular building should be reused and stored in the material bank. As a closed loop stored demolished materials can be used for the construction of new structures and buildings.(Hopkinson *et al.*, 2018).

Moreover, CE is expected to deliver economic advantages in the form of improved economy, employment growth, material savings, and decreased risk of material supply and price instability (Repp, Hekkert and Kirchherr, 2021). Sustainable construction can be identified as concepts to reach ultimate sustainable aims such as environmental responsibility, social awareness, and the economic profitability to carry forward in the built environment and the amenities for the community (Ali and Nsairat, 2009). Construction industry in Sri Lanka has been expanded dramatically during the previous decade, but concurrently it is facing environmental problems due to unsustainable construction methods (Karunasena, Athapaththu and Ekanayake, 2016). With increased construction activities, it is better to expect higher amount of resource consumption and waste disposal systems in the future. So that, it can be difficult to pay attention on sustainability of construction aspects in Sri Lanka (Liyanage *et al.*, 2019). However, Sri Lanka has more far to go before meeting global requirements for sustainable construction concepts. As indicated by the scarcity of publications in this area, sustainable construction concepts such as CE are relatively peculiar concepts for construction projects in Sri Lanka (Wijewansha, Tennakoon and Waidyasekara, 2021). Sustainable construction provides an excellent response to environmental and socioeconomic problems because it applies sustainable strategies to the entire construction period, from extraction of raw materials to planning, design, and construction of buildings and infrastructure to the demolition and waste management at the end of a project (Athapaththu and Karunasena, 2018). However, as a result of unsustainable development throughout the previous decades and its continuation, Sri Lanka faces not only environmental but also economic and social problems (Karunasena, Athapaththu and Ekanayake, 2016).

The main objective of this study is to increase the implementation level of circular economy concept and its principles for construction projects in Sri Lanka.

2. Literature Review

A. Circular Economy Concept

CE is defined as "a restorative or regenerative industrial system by intention and design". It replaces the idea of end-of-life with restoration, moves to the use of renewable energy, prevents the use of hazardous chemicals that hinder reuse, and attempts to reduce waste via improved design of materials, products, systems, and business models" (EMF, 2015). CE concept has been acclaimed internationally because the old linear economy concept, the "take make discard" paradigm, has repeatedly failed to satisfy the issues of the global sustainability, which demands sustainable economic development, environmental preservation, and the social well-being (Jawahir and Bradley, 2016). According to Kirchherr, Reike and Hekkert (2017), CE concept specifically focused on reuse, recycling and re-generate of materials and resources, when producing and using them for a purpose (Ghisellini, Ripa and Ulgiati, 2017). Also, CE concept helps to increase the life cycle of buildings by redesigning buildings with minimum changes and focuses on using renewable energy in an efficient manner (Birat, 2015). The life span of building will be expand by applying R principles in CE concept and it gives a better value for the construction project (Grdic, Nizic and Rudan, 2020).

According to the literature, CE adoption in the Sri Lankan construction industry is still in its early stages and there are three major processes: the three R principles of reduction, reuse, and recycling (Reh, 2013), which successfully contribute to the reduction of demand on global resource supplies, supporting sustainability in construction projects (Jawahir and Bradley, 2016).

B. R Principles in Circular Economy

Initially, the circular economy concept was founded on the 3R principle (reduce, reuse, recycle), but it has lately neen advanced into the 6R principle (reduce, reuse, recycle, re-design, re-classification and renewability) (Jawahir and Bradley, 2016).

The purpose of reduction is to use fewer resources per unit of value generated or to replace a higher proportion of toxic chemicals with less harmful substances per unit of value created (Ghisellini, Ripa and Ulgiati, 2017). During the pre-construction stage, the reduction principle may be put into effect by applying methods such as designing out waste, strategic design for the effective project life cycle, and design components for uniformity and modularity (Adi and Wibowo, 2020).

The "reuse" principle describes that, the reuse of any products and items that are not wasted and are reused for the same work of which they were originally used, as well as relationships between several industries in which by-products and waste from one industry can become resources and raw materials for another (Ma *et al.*, 2014). Applying of reuse principle have the ability to uplift the requirement of remanufactured items, tempt the creation of durable products with several reuse cycles, and motivate businesses to apply product take-back programs (Ghisellini, Ripa and Ulgiati, 2017).

Recycling is utilized to recover materials with usable values, resulting in a reduction in trash that must be handled or disposed (Birat, 2015). Further, the large corporations like Unilever have already produced design principles like "Design for recyclability", is used to create items, that may be reused and recycled several times (Patwa *et al.*, 2020).

The "redesign" idea highlights the significance of the design process in identifying methods to reduce trash disposal in landfills. This concept focuses on the design of objects that can be disassembled and reused when their useful lives are over (Ghisellini, Ripa and Ulgiati, 2017).

The "reclassification" principle divides materials into two categories: "technical" and "biological". The technological components are intended to be reused at the termination of the products' life cycle but the biological materials, which are often non-toxic, are intended to be returned safely to the biosphere or placed in a cascade of subsequent uses (Wijewansha, Tennakoon and Waidyasekara, 2021).

"Renewability" acknowledges renewable energy as a CE's major source of energy, and higher usage of toxic waste, when producing energy can be reduced by applying renewables (Geng *et al.*, 2013). In terms of the renewability principle, building design that supports the installation of circular economy principles of renewable energy sources may be recognized as a likely option that can be used at the pre-construction stage (Hargroves *et al.*, 2014).

C. CE in the Construction Industry

Over half of all waste created in the construction sector is linked with end-of-life activities and operations, predominantly demolition (Kibert, 2016). However, only around 30% of these components are reused or recycled (Macarthur, 2013). Present conditions and practices in the construction sector imply that CE can help the industry's sustainability. The first step is to understand how CE may help the construction sector, given that CE can help reduce the environmental effect of building operations (Ghisellini, Ripa and Ulgiati, 2017). The structures are frequently thrown away at the end of their life cycle, recent studies are not agree with that, reusing of materials in construction projects is unlikely. As an example, 45.8 million tons of waste generated annually,

as a result of demolition and construction (Akanbi *et al.*, 2018).

Present conditions and behaviours in the building sector show that, a concept like CE have the ability to help the industry to be more sustainable. The first step is to understand, how CE may help the construction sector, given that CE can help to reduce the environmental effect of building operations (Ghisellini, Ripa and Ulgiati, 2017). Moreover, resource productivity should be the key emphasis of the construction sector in the future, which might be accomplished by implementing CE principles inside the construction sector and CE adoption in the building sector is still in its early stages (Smol *et al.*, 2015). This is certainly relevant for developing countries like Sri Lanka, as indicated by the paucity of literature on the use of CE principles for the construction projects in Sri Lanka. Further, literature state that, 6R principles in CE have the flexibility to embrace adjustments to improve the sustainable practices and it will be implemented with reduced change costs at the pre-construction stage of a project.

There are recent research studies on implementing circular economy in Sri Lankan context (Wijewansha, Tennakoon and Waidyasekara, 2021; Athapaththu and Karunasena, 2018) but this study focuses on implementing circular economy and its principles for the whole life cycle of Sri Lankan construction projects.

3. Methodology

A qualitative data collection approach was followed in this study to get the idea about circular economy concept, its level of implementation in Sri Lankan construction sector and to provide a criteria to implement 6R principles in circular economy concept for construction projects in Sri Lanka. A qualitative approach is better in identifying a single piece of data or code is sufficient to incorporate it in the analytic framework (Mason, 2010). Semi-structured interview was the data collection method which was used in this study and interviews were conducted among twelve (12) construction professionals in the Sri Lankan construction sector to get their opinion on circular economy concept. Purposive sampling technique was used in this study and the sample includes project managers, engineers, designers, quantity surveyors and architects, who are having the experience in the area of sustainable construction.

4. Research Finding

This section includes the findings of the research, which were gained by semi-structured interviews.

A. General characteristics of interviewees

Table 1: General characteristic details of interviewees

Interviewee code	Designation	Type of the organization	Experience in the construction industry
E1	Project Manager	Contractor	24
E2	Project Manager	Contractor	10
E3	Project Manager	Consultant	13
E4	Mechanical Engineer	Contractor	15
E5	Civil Engineer	Consultant	09
E6	Mechanical Engineer	Contractor	14
E7	Quantity Surveyor	Consultant	22
E8	Quantity Surveyor	Contractor	12
E9	Quantity Surveyor	Consultant	08
E10	Architect	Consultant	15
E11	Designer	Consultant	08
E12	Designer	Consultant	16

B. Awareness of the Circular Economy Concept in the Sri Lankan Construction Industry and Its Advantages

According to the interviewees' point of views, they believe that, circular economy concept has been popular among countries such as Japan, Australia from few decades, but it is totally a new concept in the Sri Lankan construction industry. Further, the Sri Lankan construction sector still not adopted to circular economy and it is not implemented in a considerable manner. There are two sustainable strategies in using materials for a construction project which were identified at the interviews, "cradle to cradle" and "cradle to grave". In "cradle to cradle", materials in a particular construction project, can be used to another project with minimum modifications. But "cradle to grave", materials cannot be used for another project's beginning. Unfortunately, cradle to grave is the usual strategy in present Sri Lankan construction industry, "cradle to cradle" is only applicable for few sustainable projects.

Interviewees expressed that, the life cycle cost of a construction project can be reduced by applying circular economy concept and it provides a better value for the project.

However, interviewees' opinion was that, the most of construction professionals are still trying to complete the projects according to the project management concepts by considering only the time, cost and quality of the project. But this circular economy concept and its principles can be used to the project portfolio level and it makes the path for a flexible construction industry in the country.

C. 6R Principles in the Circular Economy Concept within the Sri Lankan Construction Industry

According to the interviewees' viewpoints, the Sri Lankan construction sector is applying the 3R principles which are reduce, reuse and recycle, but not in a proper manner. So Sri Lankan construction industry is more unfamiliar with 6R principles. Moreover, sustainable construction concepts such as green building concept also implemented in a limited level in Sri Lankan construction sector. As per the interviewees' point of view, most of the construction professionals haven't enough awareness about the 6R principles and specially on redesigning and re-classification.

However, interviewees expressed that, the natural resources in Sri Lanka to be conserved and the wastages to be minimized by applying the 6R principles of the circular economy concept. And also, it increases the energy preservation and will help to implement a better sustainable development in the Sri Lankan construction industry.

1) Reduction (R1) principle:

Under the reduction principle, most of the interviewees expressed that, while doing a construction, the wastages of resources and materials should be minimized. E4 and E6 highlighted that, the construction activities such as fabricating PVC and HDPE pipes generates a considerable wastage at construction sites in Sri Lanka. That can be occurred due to appointing unskilled labourers for that kind of activities in the construction sector. According to the E6's point of view, those kind of material wastages can be reduced by appointing skilled labourers for construction activities such as fabricating HDPE and PVC plumbing work.

When considering the reduction principle, E1, E5, E8 and E10 highlighted that, the construction industry in Sri Lanka should pay more attention to reduce, using of construction materials which are not recyclable or reusable. As examples, materials such as polythene and PVC cannot be reused and it is better to reduce using those kind of materials under the reduction principle. Also, E1 and E3 suggested that, the construction professionals and designers should pay more attention to use more recyclable materials such as glass for construction projects in Sri Lanka.

E6, E10 and E11 suggested that, a considerable amount of wastages in concrete mixing and plastering can be reduced by using new technologies for concrete mixing and wall plastering in construction projects. Further, resource consumption can be minimize by using waste where possible and there should be a proper storage location for waste material.

2) Reuse (R2) principle

When considering interviewees' opinion on reuse principle, E1, E4, and E12 expressed that, in the design stage of a construction project, it is better to select more reusable materials than recyclable materials because, there will be a higher cost for recycle process when comparing to reuse.

Under reuse principle, E4, E8 and E11 highlighted that, the demolished concrete parts from buildings can be used for filling works in road construction projects where possible. And also, those demolished parts of concrete can be used for land filling in construction projects. Also, double checking of materials before ordering materials and maintaining detailed specifications of materials can be practiced to save materials under reuse principle.

However, interviewees' opinion was that, it requires more awareness on the reuse principle in sustainable construction and it's cost effective advantages among industry professionals and the clients in the construction sector.

3) Recycle (R3) principle

When applying the recycle principle to the construction projects, interviewees were expressed that, it is better to select recyclable materials for construction according to the life span of the building.

Most of the interviewees highlighted that the glass material, to be selected as the major recyclable material for construction projects under the recycle principle. E2, E10 and E12 specifically expressed that, the glass material can be rebuilt as glass-concrete by a process and this is applying for construction industry in developed countries such as Australia, USA and United Kingdom. Further, glass-concrete is using as tiling finishes in buildings and it gives a better architectural view. Also, E2 and E10 suggested to invite construction professionals, designers and clients in the construction sector to aware of glass-concrete material, because it provides a better value for projects in Sri Lankan construction industry.

E9 and E12 suggested that, recycling paper waste in construction project offices is an effective method to save paper usage such as for project admin works and project coordination practices.

4) Redesign (R4) principle

According to redesign principle in the circular economy concept, most of the interviewees highlighted that, the designers and architects should be flexible when they are designing a building or an infrastructure in the design stage. It is better to provide some provisions to change the design or the structure after few decades to another requirement.

E1, E8 and E10 highlighted that, modular construction methods, mainly with steel and metal can be use under the redesign principle for construction of commercial buildings and buildings for temporary purposes to implement circular economy concept in Sri Lanka.

E4 and E9 specifically highlighted that, if a building cannot use as a commercial building due to the current conditions or current end user's needs, designers can change the particular building according to the needs of the end user. Further, designers should pay attention to redesign the existing building, by doing minimum changes such as changing a wall, installing a door, installing a window, fixing a partition and get the maximum usage with the remaining building's appearance and the structure.

5) Re-classification (R5) principle

Re-classification principle was the strangest principle from the 6R principles in circular economy for the interviewees and only E2, E9 and E10 have been read this principle previously. Also E2, E7 and E10 highlighted that, the designers should select more durable materials and it is better to select eco-friendly construction materials for projects.

However, interviewees highlighted that, the designers and architects should try to use reusable construction materials for projects at the design stages and save resources and materials for future usage.

6) Renewability (R6) principle

According to the interviewees' point of view, Sri Lanka has the opportunity to gain a better output from natural energy sources in the country. Most of the interviewees highlighted that the solar power can be used as the highly

available natural energy source in the country. Solar power systems can be install on top roofs of the buildings and the electricity can be generated.

E1, E8 and E12 interviewees highlighted that, the wind-power can be used as a renewable energy source to produce electricity in Sri Lanka.

E1 and E7 expressed that, Sri Lanka has the opportunity to purify rain water and use it, not only for domestic usage but also for commercial buildings, which is called "rainwater harvesting". Sri Lanka have two monsoons and there will be a great opportunity to use rain water as a renewable for a sustainable energy consumption.

E2 and E9 specifically highlighted that, the kinetic energy which is provided by water falls has the potential to circulate turbines and can turned in to electricity, according to this renewability principle. Furthermore, E2 explained that, as per the theories in fluid dynamics, the highest kinetic energy of a waterfall is in the middle area and there is an energy which can provide electricity for a mid-level building in Sri Lanka.

5. Discussion

When analysing the results of the interviews, all the interviewees expressed that, the circular economy concept and 3R principles have been used only very few mega projects in Sri Lankan construction sector and it is not applicable in small scale and middle scale construction projects. Also, implementation of 6R principles is in a very primitive stage because of lack of awareness among both internal and external stakeholders on sustainable construction concepts and circular economy concept in the country. Another significant fact was that, the construction professionals in Sri Lanka are still trying to complete construction projects only through the traditional project management concepts within the cost, given time period and to the required quality standards which are expected by the client. But this must be developed in the present construction industry in Sri Lanka and construction professionals such as project managers should pay more attention on project portfolio management and project process management. These are very significant in the sustainable construction concepts and the benefits are considerable according to the life-cycle cost analysis for the particular project at the inception and designing stages. But unfortunately, most of the clients in the construction sector are also only considering the initial investment of a project, and they are not analysing the project life cycle cost in a proper manner. So that, mostly there is not temptation for a concept such as circular economy from clients' side in Sri Lankan construction sector. Another barrier to implement the circular economy concept for the construction industry is identified during the interviews and that is lack of studies and researches in the area of circular economy concept and 6R principles in Sri Lanka.

6. Conclusion and Recommendations

This study analysed that, implementing 6R principles in circular economy concept for Sri Lankan construction industry. There are 6R principles in circular economy concept which were identified in the literature review and they were reduction, reuse, recycle, redesign, re-classification and renewability.

According to the interviewees' point of view, the above 6R principles and circular economy concept are new and unfamiliar concepts to Sri Lankan construction industry. Only 3R (reduction, reuse and recycle) out of 6R principles are applying in construction projects in Sri Lanka and those 3R also used for only few mega-scale construction projects which are following sustainable construction strategies. Further, "cradle to cradle" is one of ideal sustainable strategy for a developing country such as Sri Lanka to implement a better circular economy standards, through sustainability in construction projects. As per the interviewees' view point, the scope of the circular economy and 6R principles is to reduce material and resource wastages during the construction, considering the advantages of project life-cycle cost analysis. Moreover, the advantages of implementing circular economy concept, the study highlighted that, the life span of a building

will be expanding, essential materials and natural resources in the country will be conserved for future usage.

According to the analysed feedback of the interviewees, it can recommend that, solar power is the major renewable natural resource, which can produce electricity in Sri Lanka and government should take necessary steps to promote solar power systems not only for commercial buildings, but also for domestic buildings. Further, proper storage location for waste material, selection of eco-friendly materials as possible, adaptation for new technologies which generate minimum of wastage, applying modular construction methods, reuse and recycling of paper were highlighted at the interviews as the recommendations for implementing circular economy concept in Sri Lankan construction sector.

Most of the construction professionals and clients in the construction sector in Sri Lanka haven't enough awareness on the circular economy concept, 6R principles and the advantages of the life cycle cost management. Most of the clients are only considering the initial investment of a project and it is better to conduct awareness programmes in the field of sustainable construction, circular economy and its advantages among the construction professionals such as project managers, architects, engineers and quantity surveyors.

In Sri Lankan construction sector, project managers are still trying to complete a project according to only traditional project management parameters such as time, cost and quality of a project, but it should be par with the sustainable and circular economy concepts. This can be reduced the life cycle cost of a project, wastages of construction materials and conserve the natural resources in the country.

Circular economy concept is very crucial in the construction industry and therefore the government and the construction industry specialists should take necessary actions to promote and implement the 6R principals and other strategies of the circular economy concept in the Sri Lankan construction industry. Also it is important to have more awareness programmes on the principals of the circular economy concept with the intention to familiarize this concept among specialists in the construction industry.

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Abbrevations and Symboles

CE: Circular Economy
HDPE: High Density Poly Ethylene
PVC: Poly Vionyle Chloride

Acknowledgements

I would like to offer my sincere gratitude to Dr. A.R. Rupasinghe and Lecturer, D.M.S. Jayasuriya for their kind supervision to succeed this study. Further, I would like to be thankful to my parents, colleagues and all who supported me to complete this study in a successful manner.

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